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Original Research

Impacts of Cattle and Sheep Husbandry on Global Greenhouse Gas Emissions: A Time Series Analysis for Central European Countries

Serkan Gürlük*, Gökhan Uzel, Özlem Turan

Department of Agricultural Economics, Agricultural Faculty, Uludag University, 16059 Bursa, Turkey

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Abstract

Global warming and climate change have become issues that recently have caused much concern in the world. Countries that perform their economic activities without thinking about future generations have had to focus on "sustainability" issues since local and global environmental issues have been experienced. In this context, global warming problems have become one of the most important environmental topics occupying the world agenda and are causing intensive scientific and political discussions. One of the causes of global warming is increasing greenhouse gases, CO_2, CH_4, N_2O, CFC, etc., in the atmosphere. Especially in developing countries, growing populations, industrial development, and increasing demand for energy have triggered greenhouse gas emissions. Yet we cannot ignore the contributions of developed countries to greenhouse gas emissions. In fact, developed countries have brought the world's attention to sustainability and environmental management systems after contributing negatively to world pollution. While all these discussions are going on, a new issue is the negative effect of greenhouse gas emissions caused by animal husbandry. In order to meet the global meat demand, intensive industrial and traditional husbandry is preferred worldwide. This situation causes increased greenhouse gas emissions and may cause significant problems to the environment and to sustainable agriculture. By considering the negative contribution of animal husbandry to global warming issues, countries may have to enact reforms in animal husbandry policies or pay the price for their contribution to greenhouse gas emissions in the future. The purpose of this study is to present policy options for Turkey, EU-12 countries, and Central European countries in regards to this topic. These analyses will shed light on animal husbandry practices and contribute to the knowledge level of political decision makers and the public.

Keywords: global warming, greenhouse gases, cattle and sheep husbandry, time series analysis

Introduction

Global warming has become an issue of interest on the world agenda in recent years. Countries that performed economic activities excessively without any care for future generations have changed their focus to one of "sustainability" as they faced environmental problems, first locally then globally. In this context, global warming has become one of the important environmental problems on the world agenda and is a cause of intensive scientific and political discussions. Global warming can be defined as the increasing earth surface temperature caused by the increasing concentration of greenhouse gases (CO_2, CH_4, N_2O, CFC, etc.) in the atmosphere. According to research results, the aver-

*e-mail: serkan.gurluk@gmail.com

age earth surface temperature has increased in the last century 0.6ºC globally (1.2ºC in Europe). It is estimated that average global temperature will increase between 1.4 and 5.8ºC from 1990 to 2010 [1]. It is known that this increase in temperature will cause serious "climate change." Climate change that is caused by global warming affects all life on earth, especially human beings, directly or indirectly, by upsetting the balance of nature.

In developing countries increasing population, developing industries, and increasing energy demands have caused an increase in greenhouse gas emissions. However, when history is examined, the answers to the following questions are unclear. Who will undertake the external costs of the greenhouse gas emissions that have been created up until today? How much of the existing climate change problem is caused by the activities of developing and less developed countries? Which sectors are more responsible? These questions are still unanswered.

The Intergovernmental Panel on Climate Change (IPCC) declares that Annex I countries are responsible for about 70 to 80% of global emissions. Annex I[1)] countries are generally more industrialized as compared to the non-Annex I countries. Emissions of methane and nitrous oxide are about twice as high in non-Annex I countries as compared to Annex I countries, due to the relatively higher importance of agriculture in most of these countries [2]. Yet, less industrialized regions exist among the Annex I group, which includes Central European countries[2)].

While these debates continue, another topic of discussion is the contribution of animal husbandry to greenhouse gases and to global warming. Intensively industrial, traditional animal husbandry is the current preferred method used in order to meet global meat consumption demands. Since this production mechanism causes a high amount of greenhouse gas emissions, it may also cause great problems in the health of the environment and sustainable agriculture. In this context, studies that focus on the amount of greenhouse gas emissions and their future effects caused by animal husbandry are gaining importance. Because policy changes, reforms, removals, or meeting a certain amount of the external costs caused by pollution may come into effect in the future. An example of this would be the EU reforming its policies to meet the demands of the World Trade Organization.

In this context, the objective of this study is to reveal the greenhouse gas generation potential and future projection of Turkey, EU-12 countries, and Central European countries by making comparisons.

Agriculture is the first known production sector in the world. The first stage of development always began with agricultural production and trade. Investments toward industrialization were made with funds gained from agriculture. In addition, even if countries developed into industrial nations, they did not give up the international trade of agricultural goods. Agriculture is a very important sector for Central European countries as well. Share of the agricultural population in total population is on average 11.2% in this region. Turkey and Albania draw the attention as the two leading nations with their statistics of 19.3 and 41.1%, respectively. Slovenia, with 0.6%, has the smallest agricultural population among Central Eastern European countries [3].

Animal husbandry is an important branch of agriculture. Countries give importance to their livestock policies because red meat provides important proteins necessary for human nutrition. In regard to red meat consumption, cattle and sheep husbandry has an important share. Because of this, cattle and sheep husbandry is the focus of agricultural policies in the world. This is an important income source for Central European countries. In 2011 Turkey had the smallest share (41.3%) of value gained from livestock in total agricultural production value, while Slovenia (87.5%) was the leader. In eight of the 13 countries examined, the share of livestock production value in total agricultural production value is 50% or more [3]. When meat consumption per capita (kg/year) is examined, more striking results can be seen. While an important part of agricultural production value in Central Eastern European countries is gained through animal husbandry, red meat consumption is 11.3 kg a year on average. While this amount is close to the world average, it is considerably less than countries such as the USA (40.3), the EU (18.8), or France (28.8). Even though red meat consumption is related to cultural dietary habits, it is also closely related to animal husbandry policies.

Agriculture and animal husbandry are very important for Central Eastern European countries. It is also quite desirable that they meet domestic demand and produce a surplus that is available for export. However, agricultural subsidies and excessive protection policies that the developed countries supply to their farmers puts the less developed countries in a difficult position. As long as agricultural policies and consumption trends develop in this way, they will cause significant environmental problems. One of those problems is contribution to global greenhouse gas emissions.

Data

We use the Food and Agriculture Organization database to gather data on Greenhouse gas emissions amounts arising from cattle and sheep husbandry. Greenhouse gas emissions that are caused by agriculture have 8-15% share globally. This is mostly caused by animal production. Livestock is an especially important reason for greenhouse gas emissions. The livestock-related reasons are enteric fermentation, manure management and use, manure use as fertilizers, and manure left on land in pasturage. All agricultural contributions are given in Table 1.

Negative effects from manure management come into effect due to methane produced by leaving the manure in

1) Annex I countries are EU-28 countries, USA, Australia, New Zealland, Japan, Switzerland, Norway, and Turkey.

2) Central eastern European countries are Albania, Bosnia-Herzegovina, Bulgaria, Croatia, Czech Republic, Hungary, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, Macedonia, Turkey.

Table 1. Global ratios of agricultural greenhouse gas resources (2010).

Agricultural Greenhouse Gas Resources	1000 Ton (CO_2 equivalent)	%
Enteric fermentation	2,018,898	43.0
Manure management and use	340,285	73
Rice production	499,428	10.6
Artificial fertilizers	683,484	14.6
Farm manure fertilizers	111,11	2.4
Farm manure left on land	764,486	16.3
Production waste	153,612	3.3
Organic Land under cultivation	97,122	2.1
Burnoff	21,511	0.5
Total	4,689,936	100

facilities without oxygen or proper storage. The effects change depending on the characteristics of the manure, manure storage systems, and its handling. Its share of total agricultural greenhouse gases is 7.3%. Farm manure that has been left on the land because of pasturage has a share of 16.3%, while the percentage of farm manure used as fertilizer on farm land is 2.4%.

The Central European countries that comprise the subject matter of this study contribute only 2% to the greenhouse gases that occur globally because of cattle and sheep husbandry (Fig. 1). The effects caused by China, the USA, and France are 9%, 7%, and 2% respectively.

When the impact of the Central European countries on greenhouse gas emissions caused by cattle and sheep husbandry is examined, it can be seen that Turkey has the biggest share with 42%. Turkey is followed by Poland and Romania. Their percentages are 19% and 12%, respectively. Since 1995 it can be said that all of the countries under investigation except Bosnia and Herzegovina have reduced their greenhouse gas emissions caused by cattle and sheep husbandry. However, Bosnia and Herzegovina's share among these countries is only 2.1% (Table 2).

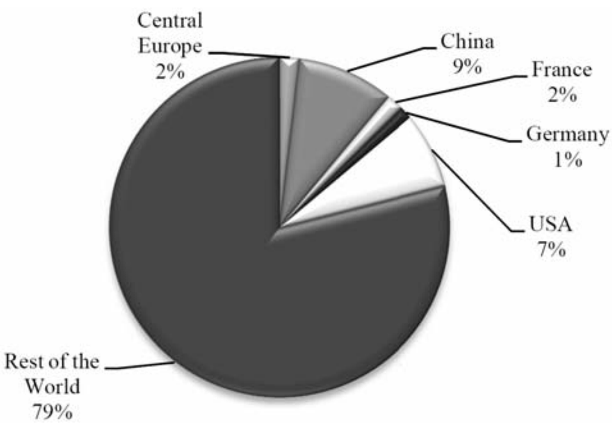

Fig. 1. Appearance of Central European countries due to CO_2 emissions arising from cattle and sheep husbandry (2010).
Source: [3]

An important component in the greenhouse gases caused by cattle and sheep husbandry is animal numbers. The total percentage share of these 14 countries under investigation regarding animal (cattle, sheep, and goat) numbers is only 2.1%. China's and USA's shares are alone 11% and 2.8%, respectively.

Global meat consumption amounts show also that in the future there may be significant issues. For example, meat consumption per capita in China increased 130% between 1990 and 2009 [4]. On a regional level, the food sector is blamed for 31% of total greenhouse gases impacts in EU-25 countries. In addition, at the national level, a developed country's food consumption is responsible for 15-28% of overall national emissions [5]. It is also important to point out that millions of potential meat consumers are joining the market. Global population was 5 billion in 1987 and increased to 7 billion in 2011. Thus global meat consumption increased to 278 million tons in 2009 while it was only 70 million tons in 1961. According to estimates, by 2050 global meat consumption will increase 65% and reach 460 million tons.

Another important indicator apart from meat consumption is the emissions created per type of food production. For example, according to research in the EU, the CO_2 equivalent of the greenhouse gas emissions for the production of 1 kg meat is 22.6 kg. The same statistic for pork is 2.5 kg; for poultry, 1.6 kg; and for milk, 1.3 kg. [6]. In the United Kingdom the CO_2 equivalent of the emissions created for 1 kg red meat production is 16 kg, while in Sweden it is 30 kg [7]. Another subject of research concerns the CO_2 emissions created by automobiles. The CO_2 equivalent of greenhouse gases created by 1 kg red meat consumption of a typical family is equal to the CO_2 equivalent of a car travelling a distance of 160 km [8]. Indeed, emissions of greenhouse gases from agricultural production, especially animal husbandry, impose externalities on the national and global levels as damage costs, these costs are not reflected in the price of foods [9]. It is one of the main reasons for excess production and consumption of foods.

Method

Data is composed of FAO long-term statistics. Central Eastern European countries that have been included in the study are Bosnia-Herzegovina, Poland, Hungary, Czech Republic, Romania, Bulgaria, Albania, Slovakia, Macedonia, Serbia, Croatia, and Turkey. The developed countries USA and EU-12 have been researched, and China also has been analyzed. Future estimates have been prepared by taking into consideration the data between 1990 and 2010 in relation to the existence of data about CO_2 equivalency of greenhouse gases caused by cattle and sheep husbandry. While data about some countries, such as Turkey, Albania, Bulgaria, Hungary, Poland, and Romania, include the years 1990-2010, data about Bosnia and Herzegovina, Croatia, Slovenia, and Macedonia include

Table 2. Historical appearance of the CO_2 emissions arising from cattle and sheep husbandry in Central European countries.

Countries	1990	%	1995	%	2000	%	2005	%	2010	%
Albania	1,898.4	2.3	2,725.3	3.6	2,299.9	3.5	2,095.1	3.6	1,735.8	2.9
Bosnia-Herzegovina			1,052.5	1.4	1,202.5	1.8	1,263.2	2.2	1,268,4	2.1
Bulgaria	4,988.3	6.0	2,294.88	3.1	2,315.3	3.5	1,970.8	3.4	1,585.8	2.6
Croatia			1,238.77	1.6	1,084.7	1.6	1,204.4	2.1	1,094.9	1.8
Czech Republic			3,979.43	5.3	3,016.3	4.6	2,661.1	4.5	2,508.6	4.1
Hungary	3,543.8	4.3	2,061.22	2.7	1,986.3	3.0	1,779.2	3.0	1,636.5	2.7
Montenegro									325.7	0.5
Poland	21,886.6	26.5	15,501.51	20.6	12,877.2	19.8	11,640.1	19.8	11,737.2	19.4
Romania	15,474.9	18.7	9,717.53	12.9	8,534.6	13.5	7,913.9	13.5	7,722.8	12.7
Serbia									2,390.9	3.9
Slovakia			1,893.02	2.5	1,387.1	1.9	1,134,9	1.9	997.2	1.6
Slovenia			984.82	1.3	898.1	1.5	872.2	1.5	886.1	1.5
Macedonia			1,082.73	1.4	821.3	1.3	771.8	1.3	732.5	1.2
Turkey	34,762.4	42.1	32,605.4	43.4	29,390.1	43.2	25,334.9	43.2	25,956.6	42.8
Total	82,554.5	100	75,137.1	100	65,813.6	100	58,641.8	100	60,759.1	100

*Gigagram (1 Gigagram = 1000 Ton)
Source: [3]

1992-2010. Data about Czech Republic and Slovakia include 1993-2010. The EU-12 countries are Austria, Belgium, Luxembourg, Denmark, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden, and the UK, and those countries' data include the years 1990-2010.

The statistical time series approach has been used as a research method because agricultural production is under the effects of nature, and natural circumstances have lagged behind effects on production decisions. In other words, these can affect the current time period t and also t+1 and t+2 next periods. In statistics, these kinds of effects are time lags and called "distributed lag." Distributed lag models require complex methods that have been used frequently in recent years. Algebraically, we can state that a dependent variable, y_t, can be explained by a policy variable, x_t. In this case the lagged values of the policy variable ($x_{t-1}, x_{t-2}, x_{t-3},\ldots x_{t-n}$) can affect the dependent variable. In some cases the dependent variable is affected by lags that develop independently. In this case, the dependent variable will depend on lagged values such as ($y_{t-1}, y_{t-2}, y_{t-3},\ldots y_{t-n}$).

In this research the dependent variable, greenhouse gas emissions caused by animal husbandry, is assumed to not be explained by another explanatory variable's lagging values. This is generally because emissions related to animal numbers can be a delayed function of production value by one or more years in the past. In other words, the dependent variable is explained only by its own past values and errors.

Some time series models can explain these kinds of events. autoregressive integrated moving average model (ARIMA) is preferred for this research. In the AR process, a random variable is dependent on its or the error term's past values [10]. In its most basic form, it is expressed as shown below.

$$y_t = \alpha + \beta_1 y_{t-1} + e_t \qquad t = 1, 2, ..., T \qquad (1)$$

In this model, α is constant term parameter and is estimated statistically. β is a parameter that will be estimated in the interval between [-1, 1] .The error term e has zero average and constant variance. In Equation 1, since y_t is dependent on its previous period and error term, it can be defined as first-order model or AR(1) process. Dependent variable y_t may not depend only on the variables of the previous year or the year before that. It may also be related to values of a few years before. In this case the AR process will be expressed as follows:

$$y_t = \alpha + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_p y_{t-p} + e_t \qquad t = 1, 2, ..., T \qquad (2)$$

Since dependent variable y_t may depend on many past years, this process can be defined as the AR(p) process. The important question here is about the number of lags that will fit the data we have. In other words, what will be the number of lags that will be used in the model? In determining the most appropriate lag amount for the model, a "partial autocorrelation" method is the most commonly used method.

The partial dependency function is the sequential dependency between (y_t and y_{t-1}), (y_t and y_{t-2}), and (y_t and y_{t-3}).

An important assumption here is that the effects caused by y_t's prior lags are accepted to be constant. For example, partial sequential dependency between y_t and y_{t-2} has the effects of y_{t-1}. Similarly, partial sequential dependency between y_t and y_{t-3} has the effects of y_{t-1} and y_{t-2}'; yet this is accepted as constant in analyses. In other words, partial sequential dependency measures the dependency between the observations that have p distance from each other by keeping the dependencies in intermediate lags (less than p) same [11]. These kinds of partial dependencies are computed by statistical software and expressed with correlograms.

In the MA(q) process, y_t is equal to the sum of a constant term and the moving average of the current and past error terms. In general form the function can be written as follows:

$$y_t = \alpha + e_t + \beta_1 e_{t-1} + \beta_2 e_{t-2} + ... + \beta_q e_{t-q} \quad (3)$$

...where e_t shows the error terms that have a zero-mean and constant variance, and $\beta_1, \ldots, \beta_n$ are the unknown constants that will define the correlation. In determining the lag numbers a method similar to AR process is used. However, instead of partial sequential dependency function, sequential dependency function is used. The sequential dependency function shows the sequential dependencies between (y_t and y_{t-1}), (y_t and y_{t-2}), and (y_t and y_{t-3}). Here y_t's effects that are caused by prior lags are not assumed to be constant.

The ARIMA process is composed of the integration of the two models mentioned above. For example, an ARIMA (1, 2) model with one sequentially dependent lag and two lags with moving averages can be written as:

$$y_t = \alpha + \beta_1 y_{t-1} + e_t + \gamma_1 e_{t-1} + \gamma_2 e_{t-2} \quad (4)$$

There are software packages that estimate these kinds of models and make it possible to make predictions. In this research STATISTICA software was used. The above-mentioned AR, MA, and ARIMA processes hypothesize an important subject. This hypothesis is "stationary." These processes assume that the series that are examined are steady. However, most economical data are known not to be steady [12]. In a steady time series, the mean, variance, and partial sequential functions do not change with time.

Non-stationary time series can be transformed into steady data. In order to do this, the differences in the series from one or more degrees can be calculated. It is an important indicator to understand a series with a non-stationary sequential dependency function. Some statistical tests are suggested for this. This paper considers Ljung-Box Q test statistic. Q stationary test, which complies with x^2 distribution, is utilized to determine if the error terms are independent of each other [11]. Many statistical software calculate necessary Q value. Generally the 25 lags are appropriate, but in the lower order models, a 15-20 lag length is considered [13-15]. In this research, the lag length used is 12-15, depending on the data. After determining the most applicable model, predictions for the future can be made. Correlograms that show the series are steady and the model results have been presented at the corresponding author's personal web page: *http://serkan.home.uludag.edu.tr/List%20of%20Selected%20Publications.htm.* Forecasts calculated by time series analysis can be seen in Table 3. According to forecasts, in 2020 there won't be an important change in the share of Central European countries. It is promising to see a possible decline in the share of EU-12 countries by 1.18%. When China's negative contributions to greenhouse gas emissions caused by cattle and sheep husbandry in 2020 is compared to 2010, it will increase 9.43%; in EU-12 it will decrease by 12.5%.

Table 3. Real data and forecasts for share of cattle and sheep husbandry in selected countries.

Countries	Real Data (2010)	Forecast (2020)
USA	7.26	6.98
China	9.26	9.62
EU-12	6.94	5.76
Central and Eastern Europe	1.81	1.84

Discussion and Policy Recommendations

Cattle and sheep husbandry is an important branch of agriculture for the Central European countries. In order to increase income from animal husbandry, subsidies should be increased. Indeed, since cattle and sheep husbandry and production are high value-added, they are an important source of income, especially for the countries examined in this study. And they also have high social importance.

Increasing red meat consumption should be an important food policy for Central European countries, because their consumption amounts are very low in comparison to the geographically close EU countries. In order to decrease the excessive red meat consumption of developed countries a "red meat consumption tax" can be levied such as a carbon tax.

Greenhouse gases that are caused by cattle and sheep husbandry are generally a result of enteric fermentation. This can be prevented by changing feed ratios and applying different feed strategies.

Greenhouse gases that are caused by cattle and sheep husbandry are only 2% of the total greenhouse gas emissions in the Central European countries. Also, we must take into account the fact that the capacity of using other inputs (inorganic fertilizers and pesticides) is lower in comparison to the EU. Central European countries can be used as agricultural production areas for the EU. This is because in the EU soil impoverishment is caused by excessive input usage and the resulting monoculture caused by industrial production which imposes an increased pressure on EU agriculture.

The ARIMA, a time series model, is an important tool in order to determine the future estimations of the effects of greenhouse gases that are caused by cattle and sheep husbandry using the historical data. After the series are made steady, the estimations should have high statistical significance. In the time series model that has been generated, estimations have been made until the year 2020 in this paper. According to these estimations, there will not be any important changes to the global share of the Central Eastern European countries in terms of greenhouse gases caused by cattle and sheep husbandry.

There are many ways to reduce the effects of emissions caused by animal husbandry. Many barriers would exist with regard to implementation of regulations including institutional, educational, social and political constraints [16]. Yet environmental regulations for every environmental issue may be solved with common action and policy priority. All segments of agriculture have management options that can reduce agriculture's environmental footprint [17]. In order to solve the problem created by the animal husbandry sector, agricultural lands should be protected because agricultural land contributes a great deal to carbon securitization. Agricultural lands must be protected, and keep cultivated lands limited to a certain amount.

Efficiency must be increased in the feeding of cattle and sheep. Instead of using soy- or corn-based feeds that cause an increase in methane, more natural feeding methods can be used [18]. Grasslands should be kept at a level of one-thirds of total land size. Keeping average farm sizes at optimum levels and applying landscape planning methods are policies that can be recommended for the sustainability of agriculture and animal husbandry.

Also, fast-food habits could be abandoned and traditional foods preferred. Poultry and pork consumption may become more widespread. However, the poultry sector requires cereal grains and soy products that may contribute to greenhouse gases in other ways.

Animals that have been bred and raised through natural methods, as well as their products are more environmentally friendly. However, in order for these products to take a larger place in the consumer's perception, better labeling should be used with these products. Also, a legal groundwork may have to be created for these [19].

Keeping greenhouse gas emissions at year 2000 levels can only be reached if 9 billion people consume 70-90 grams of red meat daily. Because of this, developed countries should be more careful. In addition to the developed countries, countries that have high economic growth such as China also need to be careful with their consumption levels. To summarize, even though greenhouse gases that are caused by cattle and sheep husbandry are an important environmental problem, they do not require a priority status in terms of policy making. However, in countries such as the USA and China that have large economies, it is an important environmental problem and should take priority in terms of policy making.

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